REPORT OF CONSTRUCTION QUALITY ASSURANCE (CQA)

DISPOSAL MODULE 4.2 LINER SYSTEM

NORCAL WASTE SYSTEMS HAY ROAD LANDFILL SOLANO COUNTY, CALIFORNIA

AUGUST 2006

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1.0 INTRODUCTION

This report presents the results of geotechnical and geosynthetic Construction Quality Assurance (CQA) observation and testing services completed during construction of the composite liner system for Disposal Module (DM) 4.2 at the Norcal Waste Systems Hay Road Landfill (NWSHRL), in Solano County, California. In general, construction of the DM 4.2 composite liner included placement of engineered general fill and low-permeability engineered fill soils for the base liner, and the installation of geosynthetic and earth materials to form the waste containment system for the expansion area. CQA activities performed by Geo-Logic Associates (GLA) included monitoring and testing of earthwork construction, geosynthetic material installation, and monitoring and testing of the leachate collection and recovery system and protective soil cover. GLA's subcontractor, Leak Location Services, Inc., also conducted a leak location survey of the completed composite liner system.

This report has been prepared for Norcal Waste Systems Hay Road Landfill, Inc. (NWSHRLI), and provides documentation and certification for mass grading, engineered fill placement, and construction of the composite liner system within the DM 4.2 area. Closure construction improvements for Disposal Module 2.2 (DM 2.2) were also completed under the DM 4.2 construction contract however, CQA reporting for this work is provided under separate cover. Construction of the DM 4.2 composite liner system was governed by the following documents prepared by Golder Associates (Project No. 053-7043).

- Contract Documents Norcal Waste Systems Hay Road Landfill, Disposal Module 4.2 Base Liner System and, Disposal Module 2.2 Side-Slope Liner System, including Scope of Work, Bid Conditions, Construction Contract, Special Conditions of the Contract for Construction, Technical Specifications, and Construction Quality Assurance Plan (CQA Plan); dated March 22, 2006.

- Construction Drawings Norcal Waste Systems Hay Road Landfill Base Liner System Disposal Module 4.2, Solano County, California, Sheets 1 through 7, dated March 2006.

The objective of the Construction Drawings and Contract Documents was to construct a composite liner system for the DM 4.2 area that meets Waste Discharge Requirements (WDR) Order No. R5-2003-0118, and the applicable requirements of federal Subtitle D regulations and Title 27 of the California Code of Regulations (CCR).

This CQA Report summarizes construction activities and documents the CQA observation, monitoring and testing performed by GLA during construction of the DM 4.2 base liner system.

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1.1 PROJECT DESCRIPTION

DM 4.2 encompasses an area of approximately 6 acres and is bordered on the north by existing DM 5.2, on the east by existing DM 4.1, and on the northeast by existing DM 5.1. DM 4.2 is bordered on the south by native ground and on the west various access roads used for landfill operations. Sheet 2 of the Construction Drawings shows the location of DM 4.2 in relation to existing site facilities.

The base grades for the northern most section of DM 4.2 slope at two percent toward leachate collection lines oriented in a north-south direction. These collection lines were placed at a grade of one percent and ultimately connect to the leachate collection lines for the adjacent DM 5.2 liner system at the north end DM 4.2. The base grades for the southern three-quarters of DM 4.2 slope at two percent toward leachate collection lines oriented in an east-west direction which also flow at a one percent gradient but connect the leachate collection lines and base liner grades for the adjacent DM 4.1 liner system at the eastern termination of DM 4.2.

Construction of the double composite liner system for the DM 4.2 base liner is composed of the following components (from bottom to top):

- General Earthfill with the upper 6-inches constructed using clayey soils.
- Installation of a double-sided textured 60-mil HDPE geomembrane to serve as the secondary leak detection liner.
- Installation of the leak detection geocomposite composed of a geonet encapsulated between two non-woven geotextiles.
- Placement of a 2.5-foot thick compacted low-permeability clay liner with the upper 2-foot thick section having an in-place hydraulic conductivity of less than 1.0 E-07 cm/sec.
- Installation of a double-sided textured 60-mil HDPE geomembrane to serve as the primary containment system.
- Placement of a 6-inch thick leachate collection and removal system (LCRS) composed of select import gravel and 4-inch diameter perforated HDPE collection pipes.
- Installation of an eight (8) ounce per square yard non-woven geotextile filter fabric.
- Placement of a one (1) foot thick operations layer composed of a mixture of on-site soils and biosolids.

CQA documentation relative to construction of the DM 4.2 base liner system is included in this report or as attachments to this report. Project documentation includes Tables 1 through 7 that summarize the field and laboratory soil test results and Plate 1 that presents the Field and Laboratory Test Location Plan. Verification survey for the various individual components or layers of the base liner system was performed by the Contractor and submitted to GLA for review. These As-Built Drawings are included as Plates 2 through 8. Appendices A through G include supporting documentation, construction photographs, laboratory test results, geosynthetic material certifications and laboratory test results, reports relative to the liner leak detection survey, and Daily Field Reports prepared by GLA's CQA monitor during construction.

1.2 PROJECT ORGANIZATION AND SCHEDULE

The DM 4.2 composite liner system construction was governed by the Contract Documents and Construction Drawings (Sheets 1 through 7) prepared by Golder Associates, dated March 2006. The general contractor for the DM 4.2 project was Boston Pacific, Inc., who also performed all earthwork construction for the project. The subcontractor for geosynthetic material installation was D&E Construction, Inc. HDPE geomembrane materials used for the project were supplied by Poly-Flex, Inc. The 8-ounce per square yard non-woven geotextile, and the geocomposite were supplied by SKAPS Industries, Inc.

NWSHRLI provided construction management services and Golder Associates provided engineering support services for the project. GLA provided CQA observation, monitoring, and testing services in accordance with the approved CQA Plan and Technical Specifications. Geosynthetic material conformance and destructive seam testing was performed by Precision Geosynthetic Laboratories, Inc., under contract to GLA. The liner leak location survey was performed by Leak Location Services, Inc., also under contract to GLA. Survey verification of composite liner system components was provided by the General Contractor and reviewed by GLA for conformance with the project specifications.

The Contractor's Notice-to-Proceed for the DM 4.2 Base Liner System Project was issued on May 11, 2006 and Contractor operations continued relatively uninterrupted from that date through the project substantial completion date of August 10, 2006. General earthfill construction began May 15, 2006 and continued as dictated by the contractor's schedule through June 20, 2006. Geosynthetic material deployment began on June 26, 2006 and was completed on July 20, 2006. Placement of the operations layer in the DM 4.2 area was complete on August 3, 2006, and the leak location survey was completed on August 6, 2006.

GLA performed Construction Quality Assurance (CQA) observation, monitoring and testing during earthwork and geosynthetic material installation through the substantial completion date. This report presents the results of CQA field and laboratory test results obtained and field observations made during construction of the DM 4.2 base liner system.

2.0 GENERAL GRADING

2.1 SUBGRADE PREPARATION AND GENERAL EARTHFILL

The subgrade preparation for construction of the DM 4.2 base liner area consisted of scarifying, moisture conditioning, and compacting the existing on-site soils, and then placing the general earthfill to the lines, grades and tolerances of the design drawings. Prior to general earthfill placement, existing subgrade materials were scarified, moisture conditioned as necessary, and compacted in accordance with the Project Specifications. General earthfill soils, consisted of clayey silt with sand to silty clay derived from the designated on-site borrow area. Approximately 92,000 cubic yards of general earthfill was excavated from the designated on-site borrow area, transported to the DM 4.2 area using bottom dump trucks, and placed as compacted fill. These soils were moisture conditioned as necessary and placed in thin (6- to 8-inch) horizontal lifts to design subgrade elevation. General earthfill materials were placed at approximately optimum moisture content and a minimum relative compaction of 90 percent based on the maximum dry density as defined by ASTM D1557. Compaction effort for the general earthfill materials was provided by pneumatic wheelrolling with the equipment and by a CAT 815 compactor. Clayey soils were utilized in the upper 6-inches of the subgrade and these materials were then rolled with a smooth steel drum roller prior to geomembrane liner deployment.

During general earthfill placement, the CQA Monitor observed and tested the fills in the DM 4.2 base liner area to evaluate contractor compliance with the requirements of the Project Specifications. The results of the CQA test performed in the engineered fill are summarized in Tables 1 and 2 and Plate 1 presents the approximate locations of the field tests performed during construction.

2.2 LOW-PERMEABILITY LAYER

2.2.1 TEST PAD WAIVER

On May 18, 2006, prior to the start of low-permeability material placement, the Design Engineer and NWSHRLI submitted a letter to the Regional Water Quality Control Board (RWQCB) requesting that the requirement to construct a test pad be waived. As stated in the May 18, 2006 letter, this waiver request was based on three factors: 1) construction of the DM 4.2 low-permeability liner would use the same borrow source as that characterized in Golder's borrow study in 2003 and would use the same materials used for construction of the DM 5.2 liner system; 2) a successful test pad was constructed and tested using the same borrow source during construction of the DM 5.2 liner system; and 3) the same contractor and equipment as that used for the DM 5.2 liner would also be used for DM 4.2 liner construction.

On May 25, 2006, the RWQCB issued a letter accepting the waiver of the test pad requirement and as a result the test pad was deleted from the project. Both the May 18, 2006 letter requesting the test pad waiver, and the May 25, 2006 letter from the RWQCB accepting the waiver are included in Appendix A.

2.2.2 LOW-PERMEABILITY LAYER MATERIALS AND CONSTRUCTION

As noted above, materials for the low-permeability liner were obtained from the designated borrow area located west of the DM 4.2 construction area. These borrow soils were previously characterized in a borrow investigation and this characterization was reported by Golder Associates in 2003. These low-permeability borrow soils were also used for the construction of the DM 5.2 liner system completed in 2004. Low-permeability layer soils were obtained exclusively from the designated borrow area and transported to the DM 4.2 area using bottom dump trucks. Low-permeability soils were moisture conditioned (or dried) as necessary and processed with a bulldozer, motor grader, and water truck to produce a homogeneous material prior to compaction.

The low-permeability layer was constructed directly on top of the leak detection geocomposite, and the first lift was placed approximately 12-inches thick to avoid damage to the underlying geosynthetic materials. As shown on the Construction Drawings, the low-permeability layer is 2.5-feet thick with only the upper 2-foot section required to have an in-place saturated hydraulic conductivity of 1.0 E-07 cm/sec or less.

Within the upper 2-foot thick layer, low-permeability soils were placed in thin lifts (6-to 8-inches), at a moisture content of at least 16 percent, and compacted to a minimum of 90 percent relative compaction using a CAT 815 steel-wheel compactor.

CQA laboratory and field tests were performed during placement operations in conformance with the Project Documents to document material engineering properties and relative compaction. CQA laboratory and field testing included: in-situ moisture/density using a nuclear gauge (ASTM D-2922 and D-3017) and sand cone (ASTM D-1556) methods, laboratory moisture content (ASTM D-4643), grain-size distribution (ASTM D-422), Atterberg Limits (ASTM D-4318), maximum dry density/optimum moisture content (ASTM D-1557), and hydraulic conductivity (ASTM D-5084). The results of the CQA testing performed on the low-permeability liner soils is summarized in Tables 1, 3, 4, and 5, and the laboratory test sheets are included in Appendix C. The approximate test and sample locations are shown on Plate 1.

As shown in Table 4, the low-permeability layer material generally consists of brown silty clay with a Unified Soil Classification of CL or CH per ASTM D-2487. As shown on Table 4, the low-permeability soils exhibited an average percent passing the #200 sieve of 89.8 percent, and an average percent finer than 5 microns of 53.3 percent. The results of Atterberg Limit tests indicate an average Liquid Limit (LL) of 48, and an average Plasticity Index (PI) of 48. Laboratory saturated hydraulic conductivity testing of relatively undisturbed ring samples resulted in an average in-situ hydraulic conductivity of 2.0 E-08 cm/sec.

The low-permeability liner soils placed on the DM 4.2 base liner area were over built and trimmed back to finish grade prior to deployment of the overlying geosynthetic materials. In addition, prior to geosynthetic material deployment, minor imperfections in the finished surface of the low-permeability layer were corrected as necessary, and the base liner area was rolled with a steel drum roller.

3.0 GEOSYNTHETIC LINER MATERIALS

3.1 HDPE GEOMEMBRANE

The geomembrane liner for the DM 4.2 base liner area consisted of: 60-mil high-density polyethylene (HDPE) geomembrane which was textured on both sides. The HDPE geoemembrane was installed in two layers. The first geomembrane liner was identified as the "secondary geomembrane liner" and placed as part of the leak detection system (LDS). This secondary geomembrane was installed over the general earthfill subgrade once the grading and surveying of the general earthfill was completed and approved. The overlying geomembrane liner was identified as the "primary geomembrane liner" and was placed over the low-permeability clay layer once the grading and surveying of the low-permeability layer was complete. As described below, both the primary and secondary geomembrane liners were installed in general conformance with the Project Drawings and Specifications.

The Contractor and geomembrane manufacturer submitted material certifications and manufacturer quality control (MQC) test results for the HDPE geomembrane that indicated the materials met the minimum requirements of the project specifications. In addition to the manufacturer certifications and MQC test results, conformance samples of the geomembrane materials were obtained at the manufacturing plant by Precision Geosynthetic Laboratories and tested in the laboratory to verify that the materials were in conformance with the Project Specifications.

These manufacturer certifications, the MQC test results, and the results of applicable conformance testing are included in Appendix D.

3.2 GEOMEMBRANE CONSTRUCTION

Once the general earthfill and low-permeability layer on the base liner area were prepared and approved, deployment of the geomembrane was initiated. Geomembrane materials were placed to minimize wrinkling and "bridging" of the liner across grade transitions.

Upon deployment of the lining material, each panel was identified, logged and marked with a contrasting marker and Geomembrane Panel Placement Logs were compiled (Appendix D). Prior to field seaming, each panel was observed for texturing roughness and also for evidence of defects. Any faulty areas were either removed or marked and repaired. During placement of the HDPE, all field seams were also observed prior to welding to verify that the specified minimum overlap between adjacent panels was provided and that a shingled field seam layout was being utilized.

Geomembrane panels were field seamed using double hot wedge welders and extrusion welding was used on patches, at panel intersections, at destructive sample/repair locations and in other areas where wedge welding was not feasible. Installation of the HDPE geomembrane was monitored and documented by the CQA Monitor(s) throughout construction. CQA monitoring and documentation during geomembrane installation included: monitoring and recording daily seam trial welds; compiling Geomembrane Panel Placement Logs including documentation of installation and test results for each panel placed; compiling Geomembrane Seaming Log Summaries documenting the results of seam air tests and vacuum box tests; and overseeing the sample collection and laboratory testing of destructive seam samples. Quality assurance monitoring during geomembrane installation was performed in general conformance with the Project Specifications and the Project CQA Plan and copies of forms summarizing the CQA documentation and test results compiled during installation of the geomembrane are included in Appendix D.

3.3 GEOCOMPOSITE AND GEOTEXTILE

The geocomposite and geotextile manufacturer (SKAPS) submitted material certifications and manufacturer quality control (MQC) test results for the geocomposite and 8-ounce per square yard non-woven geotextile that indicated these materials met the minimum requirements of the project. In addition to the manufacturer certifications and MQC test results, conformance samples of the geocomposite and geotextile materials were obtained at the manufacturing plant by Precision Geosynthetic Laboratories and tested in the laboratory to verify that the materials were in conformance with the Project Specifications. These manufacturer certifications, MQC test results, and the results of applicable conformance testing are included in Appendix E.

The geocomposite consists of a geonet core with an 8-ounce per square yard non-woven geotextile on each side of the geonet. The geocomposite was placed over the secondary geomembrane liner as part of the LDS of the base liner. Adjacent panels of the geocomposite were secured with zip ties at the specified spacing through the geonet core. The upper geotextile flaps were secured by sewing.

An 8-ounce per square yard non-woven geotextile was also installed as a separator filter fabric between the LCRS gravel and the overlying operations layer. Deployment of this 8-ounce geotextile was begun once significant portions of the LCRS gravel layer was completed and approved. Geotextile panels were placed and logged, then seamed to adjacent panels, by welding.

Installation of the geocomposite and geotextile was monitored and documented by the CQA Monitor throughout construction. CQA monitoring and documentation during geocomposite/geotextile installation included: monitoring and documenting panel placement and monitoring the coverage of seam sewing or welding equipment.

Manufacturer Certifications and MQC test results, and the results of the conformance tests for the installed geocomposite and geotextile are included in Appendix E.

4.0 LEACHATE COLLECTION AND RECOVERY SYSTEM (LCRS)

The leachate collection and recovery system (LCRS) consists of a 6-inch thick blanket gravel layer composed of imported 3/8-inch gravel which acts as a collection blanket feeding perforated 4-inch diameter HDPE pipes installed in accordance with the Construction Drawings. The LCRS gravel was supplied by Teichert from the Esparto Plant and placed by the Contractor using a CAT D-6 low-ground pressure (LGP) bulldozer operating on a minimum of 6-inches of gravel. During gravel delivery, representative samples were collected by the CQA Monitor and tested in the laboratory for grain-size distribution (ASTM D-136), permeability (ASTM D-2434), and percent fractured faces (ASTM D-5821). A total of three LCRS gravel samples were tested in the laboratory with all three samples indicating conformance with the project requirements. The laboratory test results for the LCRS gravel samples are summarized in Table 6, and the actual laboratory test reports are included in Appendix C.

In constructing the LCRS drainage blanket, caution was used to avoid damage to the underlying geosynthetics and no equipment was allowed to travel directly on the liner. During initial LCRS gravel placement, the material was truck dumped adjacent to the liner limit and spread out across the floor using the LGP bulldozer. The Contractor also developed 2-foot thick access ramps out onto the floor area, to accommodate material placement and minimize the push distance for the LGP bulldozer. All other equipment operated on over-thickened (minimum 2-foot thick) access ramps.

During placement and spreading of the LCRS gravel, the CQA Monitor observed the Contractor's operation to verify compliance with the Project Specifications and only one area of damage to the underlying geosynthetic materials was observed. This area was immediately repaired. After finish grading of the LCRS gravel layer, the CQA Monitor verified gravel thickness by digging through the gravel at approximately 50-foot by 50-foot grid spacing. Plate 1 shows the locations of the field measurements of the LCRS gravel and these measurements indicate the gravel thickness is within design tolerance.

The pipe used in the LCRS consisted of four-inch diameter perforated HDPE pipe that was placed in general accordance with the Project Specifications and Drawings. The CQA Monitor observed the installation of the LCRS pipe and the completed pipe and drainage gravel installation was surveyed by the Contractor. The results of this survey are included in Plate 6.

5.0 OPERATIONS LAYER

Upon completion of the 8-ounce non-woven geotextile layer over the LCRS, a one-foot thick operations layer was placed over the geotextile. The contractor staged operations layer placement with completion of portions of the LCRS gravel and 8-ounce geotextile to minimize the distance the subsequent LCRS gravel would be pushed across the cell floor. A CAT D-6 LGP bulldozer was used to spread the 1-foot thick operations layer soil onto the 8-ounce geotextile. The operations layer material consisted of a mixture of on-site soil and biosolids obtained from designated on-site stockpiles.

Operations layer material placement was observed and monitored by the CQA Monitor and no equipment was allowed to operate directly on the geotextile during placement. During placement operations the CQA Monitor performed field moisture content tests and observed that the materials were generally limited to a 3-inch minus grain size over the base liner area, and 1-inch minus along the slopes of the western and southern terminations. The results of field moisture tests obtained in the operations layer are summarized in Table 7.

6.0 LINER LEAK DETECTION SURVEY

GLA retained the services of Leak Location Services, Inc. (LLSI), to perform the liner leak detection survey as required by the Project Specifications. The liner leak detection survey was performed following placement of the LCRS gravel and operations layer soils to locate any holes or leaks in the geomembrane that might have been caused by the placement of the overlying materials. LLSI's report of the leak location survey is included in Appendix F.

As noted in the LLSI Report, two holes or leaks were detected in the primary geomembrane liner. Leak #1 was located at the northern end of DM 4.2 and leak #2 was located at the southern end of DM 4.2. Leak #1 was described as an approximately one-inch long semi-circular cut approximately one-inch in diameter, and Leak #2 was described as a linear break or tear with rough edges. Both leak locations were patched by the contractor under the observation of the CQA monitor and the location of these repairs were surveyed.

GLA's CQA Monitor observed and monitored the leak location survey performed by LLSI as well as the repairs of the two detected leaks.

7.0 CQA FIELD AND LABORATORY TESTING

Geo-Logic Associates performed CQA observation, monitoring, and testing of the earth and geosynthetic materials placed as part of the DM 4.2 grading and composite liner system construction. The Construction Quality Assurance (CQA) program employed by Geo-Logic Associates was in general conformance with the Project Specifications including the Construction Quality Assurance (CQA) Plan of the Project Specifications.

The test results and documentation of the CQA program that was implemented during construction are presented in Tables 1 through 7 and in Appendices A through G, and are summarized in the following sections of this report. Plate 1 presents a Test Location Plan showing the location of CQA tests obtained during DM 4.2 construction. Plates 2 through 8 include as-built record drawings provided by the contractor of the various components of the base liner system.

7.1 EARTH MATERIALS

General earthfill placed to achieve design subgrade elevations, and low-permeability fill were generated from excavation of on-site native soils within the designated borrow area. General earthfill materials were placed at approximately optimum moisture content to a minimum compaction of 90 percent relative to the maximum dry density as defined by ASTM D1557. In addition, the upper six inches of the general earth fill were constructed using clayey soils. Materials used for the low-permeability layer of the composite liner were composed of processed and select materials that were moisture conditioned to a minimum of 16 percent by weight moisture content and these materials were compacted to a minimum of 90 percent density relative to ASTM D1557 maximum density.

During the processing and placement of general earthfill and low-permeability layer materials, field and laboratory testing was performed to document the engineering properties of processed and compacted general earthfill and low-permeability liner soils. To provide a basis for comparing field compaction test results and in order to document the engineering characteristics of the constructed earth materials, the maximum dry density and optimum moisture content of the various earth materials were determined in accordance with ASTM D1557. A total of ten (10) maximum dry density/optimum moisture content tests were obtained for the general earthfill, and five (5) maximum dry density/optimum moisture content tests were obtained for the low-permeability layer materials.

The results of these laboratory tests are summarized in Table 1 and the laboratory test sheets are included in Appendix C.

The relative compaction of the general earthfill and low-permeability liner soils placed within the base liner area were evaluated by field and laboratory testing and field observations completed throughout the course of construction. Field density tests were obtained using the sand volume (ASTM D-1556) and nuclear gauge (ASTM D-2922 and D-3017) test methods. A total of two hundred and thirty nine (239) moisture/density tests were performed for the general earthfill and a total of ninety-six (96) field moisture density tests were taken in the low-permeability liner section of the composite liner. The results of the field compaction tests obtained for the general earthfill and low-permeability layer are summarized in Tables 2 and 3 and the approximate test locations of these tests are shown on Plate 1.

During construction of the low-permeability layer of the liner, the saturated hydraulic conductivity characteristics of the compacted soils were evaluated by laboratory testing methods. Laboratory tests of relatively undisturbed drive ring samples obtained from the completed low-permeability layer were performed in general accordance with ASTM D5084. During low-permeability layer construction a total of fourteen (14) saturated hydraulic conductivity tests were performed in the laboratory. In addition to saturated hydraulic conductivity testing, low-permeability layer soils were also tested in the laboratory for grain-size distribution (ASTM D422), Atterberg Limits (ASTM D4318), in-place moisture content (ASTM D-4643), and Unified Soil Classification. The results of the saturated hydraulic conductivity tests and engineering classification tests are summarized in Table 4 and 5, and the laboratory test sheets are included in Appendix C. The approximate locations of the saturated hydraulic conductivity test samples are shown on Plate 1.

During construction of the LCRS gravel layer, the drainage gravel was tested in the laboratory for fractured faces (ASTM D5821), permeability (ASTM D2434) and grain-size distribution (ASTM D422). Three (3) LCRS gravel samples were also tested in the laboratory for grain-size distribution and fractured faces, and two (2) LCRS gravel samples were tested in the laboratory for permeability. The results of these laboratory tests are summarized in Table 6 and the laboratory test sheets are included in Appendix C.

During placement of the operations layer material, the CQA Monitor completed field observations to verify conformance with the 3-inch and 1-inch minus criteria of the Project Specifications. Since the only specified gradation requirement was for maximum particle size of 3-inches for deck areas and 1-inch for slope areas, field testing was limited to visual observation and physically measuring particle sizes in the field. In addition, seven (7) representative samples of operations layer material were tested for moisture content in accordance with ASTM D-4643. The results of these tests are summarized in Table 7.

7.2 GEOMEMBRANE LINER

As required by the Project Specifications, Manufacturer's Quality Control Certificates and test results were obtained for the geomembrane rolls delivered to the site and for the parent resin batch from which the rolls were manufactured. All roll and resin certificates were reviewed and found to be in general conformance with the Project Specifications. Copies of these certificates are presented in Appendix D.

Upon delivery, all geomembrane rolls were inspected for visible damage and unloaded and stored in accordance with the Project Specifications and/or manufacturer's recommendations. Conformance samples were obtained at the specified frequency under the direction of the CQA laboratory. All conformance samples were labeled and transported to the independent testing laboratory (Precision Geosynthetic Laboratories) for testing. The results of the conformance tests are also included in Appendix D.

In compliance with the Project Specifications, interface direct shear testing in accordance with ASTM D5321 was conducted for the specified interfaces. This testing was conducted to evaluate whether actual liner materials would meet the minimum design strengths required in the Project Specifications. The results of the interface shear tests conducted as part of the material conformance testing were submitted to the Design Engineer and were determined by the Design Engineer to meet the project design strength requirements. The results of the interface direct shear test are presented in Appendix D and a letter from the Design Engineer (Golder Associates) confirming conformance with the design is included in Appendix A.

Field seam trial welds were completed by the liner Contractor in general accordance with and at the frequency required by the Specifications. The test results are recorded on the Geomembrane Seam Trial Weld forms included in Appendix D. During production welding, all field seams were tested using the Air Pressure Test. Seams made by extrusion welding for patches or repairs were vacuum box tested. Any deficiencies found during seam testing were marked and repaired. Geomembrane Seaming Logs were compiled during the seaming work and are also included in Appendix D.

Destructive samples of welded field seams were tested for bonded seam strength and peel adhesion as called for in the Project Specifications. Destructive samples were removed from field seams at prescribed intervals (approximately one per 500 lineal feet) and transported to the CQA geosynthetic material laboratory for testing. Based upon the results of observations and destructive seam testing, all field seams were determined to be of sufficient integrity. The results of the destructive sample testing program, as well as all other forms completed in conjunction with the geomembrane quality assurance program are presented in Appendix D.

7.3 GEOCOMPOSITE AND GEOTEXTILE

Quality Control (QC) Certificates for the geocomposite and geotextile rolls were submitted by the manufacturer prior to delivery of the material to the site. The QC certificates were reviewed and found to be satisfactory.

Conformance samples of the geocomposite and geotextile rolls were obtained from the manufactured rolls at the specified frequency and under the direction of the CQA laboratory (Precision Geosynthetic Laboratories) and these conformance samples were delivered to the geosynthetic material laboratory for testing. The results of the geocomposite and geotextile conformance testing along with the manufacturer certifications and QC test results are included in Appendix E. All on-site geocomposite and geotextile storage was conducted either in compliance with the Specifications or as recommended by the Manufacturer. All forms completed in conjunction with the geocomposite and geotextile quality assurance program are presented in Appendix E.

8.0 PROJECT DOCUMENTATION

As-Built Drawings based on survey information compiled during construction by the contractor are included as Plates 2 through 8.

Written daily progress reports detailing construction activities for each day were prepared by the CQA Monitor and submitted to the Construction Manager for project management purposes. Copies of the Daily Reports are included in Appendix G. Project correspondence and memoranda were also submitted to or from the Design Engineer during the course of construction to document issues related to construction activities and/or provide recommendations for remedial designs. Copies of these relevant documents are included in Appendix A.

The CQA Monitor maintained a photographic record of construction activities as the project progressed. Appendix B includes a sampling of the photographs to document key stages of the DM 4.2 base liner construction.

9.0 CONCLUSIONS

9.1 GRADING AND EARTHWORKS

CQA laboratory and field testing was performed at the minimum frequency identified in the Project Specifications and CQA Plan. Based on our observations and tests, it is concluded that the subgrade was properly prepared, as required, prior to general earthfill construction. Based on the observations and tests completed during fill placement, it is also our opinion that accepted construction practices and testing procedures were followed and that observed general earthfill and low-permeability layer fills were placed and compacted in general conformance with the Project Drawings and Specifications. Finally, based on the and tests, it is concluded that the subgrade was properly prepared, as required, prior to general earthfill construction. Based on the observations and tests completed during fill placement, it is also our professional opinion that accepted construction practices and testing procedures were followed and that observed general earthfill and low-permeability layer fills were placed and compacted in general conformance with the Project Drawings and Specifications. Finally, based on the field and laboratory saturated hydraulic conductivity test results obtained during construction, it is our professional opinion that the in-place hydraulic conductivity of the low-permeability layer soils are in conformance with the specified requirements.

The results of the CQA Program indicate that the minimum project requirements for earthworks construction have been satisfied.

9.2 GEOSYNTHETICS

The CQA Program employed for the geosynthetic material components of the DM 4.2 base liner system indicate that the geosynthetic materials met the specified material requirements and were installed in general conformance with the Project Drawings and Specifications. Based on this quality assurance program, it is our professional opinion that the as-constructed geosynthetic materials are in general conformance with the Project Drawings and Specifications.

10.0 CLOSURE

This report has been prepared in accordance with generally accepted geotechnical practices and makes no other warranties, either expressed or implied, as to the professional advice or data included in it. This report is based on the project as described and the data obtained in the field and the laboratory, or from referenced documents. This report has not been prepared for use by parties or projects other than those named or described herein.

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